

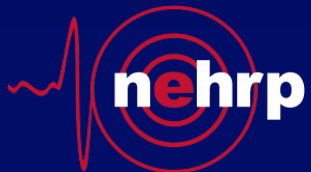
National Earthquake Hazards Reduction Program

... a research and implementation partnership

NIST Earthquake Engineering Program Overview

Advisory Committee on Earthquake Hazards Reduction

April 30, 2019



FEMA

NIST
National Institute of
Standards and Technology



USGS
science for a changing world

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Earthquake Engineering Group (2EG) Program Overview

Major Program Elements:

1. Improved Building Code Provisions for Lateral Force-Resisting Structural Elements and Systems
2. Performance-Based Seismic Engineering (PBSE) for New and Existing Buildings
3. Tools & Guidelines for Improved Earthquake Engineering Practice

These are reflected in four current thrust areas



Earthquake Engineering Group (2EG)

Thrust 1: Existing Buildings

Pre-Northridge Panel Zones
EBF Links
FRP retrofitted systems
Nonductile RC Columns

Thrust 2: EQ design in wind communities

Evaluation of buildings in Central
and Eastern US
Support of NCST Investigation

Thrust 3: Performance-based seismic design

Collapse Assessment of Buildings
Quantification of Uncertainties
Walls with High Strength Bars
Steel Wide-Flange Beam Columns
Energy-Based Collapse Assessment
~~Immediate Occupancy-Functional Recovery~~

Thrust 4: NEHRP

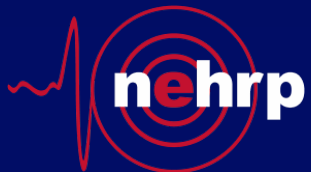
Earthquake Engineering Group (2EG)

Progress in FY2019 has been delayed by:

- External Factors
 - The month-long Federal shutdown, pushing projects back nearly a quarter.
 - Deployments
 - Anchorage earthquake in January
 - Hurricane Michael in December
 - Ongoing support for the post-event work for Hurricane Maria.
- New research directives
 - Required functional recovery study has significantly impacted project work.



Thrust 1: Existing Buildings

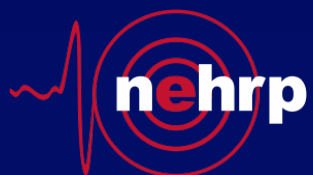


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Reliability of Fiber Reinforced (FR) Composite Systems in Resilient Infrastructure (Underway)

Thrust 1

- Problem: FR composites have been used to repair, retrofit, and strengthen infrastructure,
 - to what extent does the structural performance improve after application of FR composites?
 - it is not clear how the performance of FR composites change over time.
- Who is involved? A collaborative effort between NIST Materials Groups and 2EG
- A workshop was held on May 15th 2018 to identify the research needs
 - a report based on the workshop to be published soon.
- Recon trip to Anchorage in January looked at FRP retrofits
- Future research will focus on
 - Develop test methods (inspection methods) to quantify the response
 - Experimental studies on FRP retrofitted components
 - Impact of degradation due to environmental factors

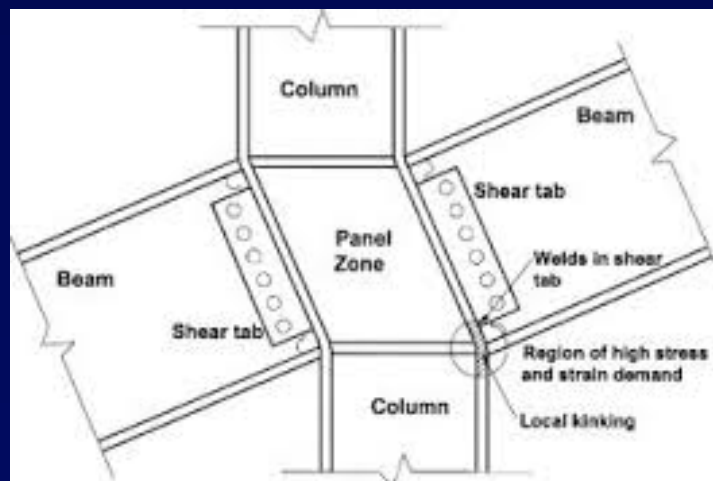


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Seismic Assessment and Retrofit of Pre-Northridge Earthquake Panel Zones in Steel Moment Frames (Underway)

Thrust 1

- Problem: Panel zones in existing older pre-1990's steel buildings were not designed to current approaches and may be under capacity



- Combination of experiments at NIST and high-end analyses will be used to study behavior to suggest ways to improve performance
- Results used to develop new assessment criteria for ASCE 41
- Provide guidance on retrofit approaches of panel zones for existing buildings based on this research



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Develop New Performance Assessment Criteria for EBF Links (Underway) *Thrust 1*

- Problem: Existing assessment criteria do not address loading history
 - Establish a new performance-based assessment criteria capturing a component's dependence on loading history (the form of the cyclic response)
- Conduct a set of focused experimental tests and computer simulations on eccentrically braced frame link beams to develop these criteria
- Collaborating with CoE researcher Dr. Hussam Mahmoud at Colo State

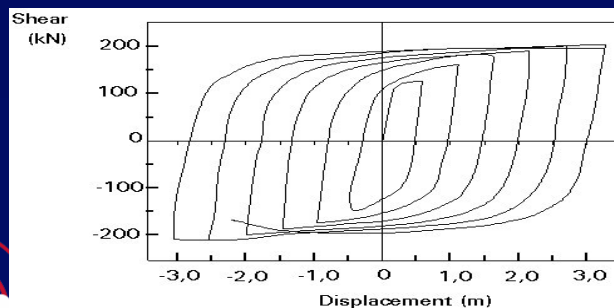
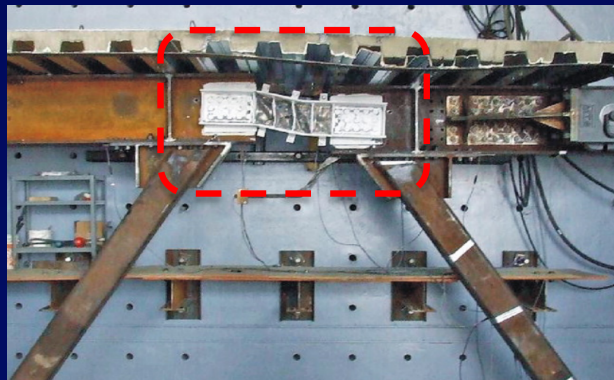


Figure 26 Hysteresis loops of a link

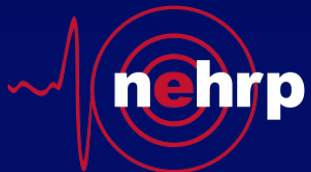


Collapse Performance Modeling of Nonductile Reinforced Concrete Columns (Underway)

- Problem: Older pre-1980 concrete columns pose a high risk of collapse on existing buildings given the poor detailing practices of the era. There is a need to improve the simulation capabilities to capture the response of these columns
- The project has two phases: 1) developing a new column model, 2) assess the collapse performance of older RC buildings
- The first phase is being conducted by a team from University of Texas (DRI awardee).
- The second phase will be conducted mainly at NIST (FY 2020).
- A workshop/webinar is being organized to present the ongoing effort to practicing engineers and city officials in LA.



Thrust 2: EQ design in wind communities

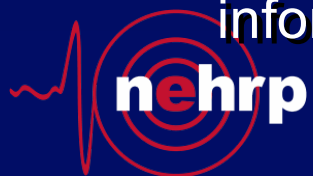


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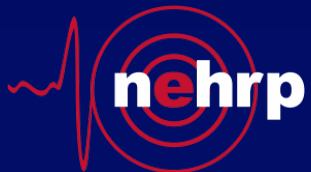
Evaluation of low- and mid-rise buildings in Central and Eastern US (CEUS) (Underway)

Thrust 2

- Problem: The effect of wind-dominant design on the seismic performance of steel buildings built in the CEUS has not been formally quantified. Nor has the effect of not including seismic detailing on these buildings been evaluated.
- A suite of structural steel and concrete buildings is being designed for multiple locations (e.g. Charleston, Memphis, and Long Island) for current and older building codes
- The seismic collapse performance of these buildings will be evaluated
- The impact of detailing on the seismic performance of these buildings will be identified.
- The outcome of this project could lead to potential construction savings and improved performance in CEUS.
- Collaborative work with the CoE and the NCST investigation; information from Hurricane Maria work can inform the study



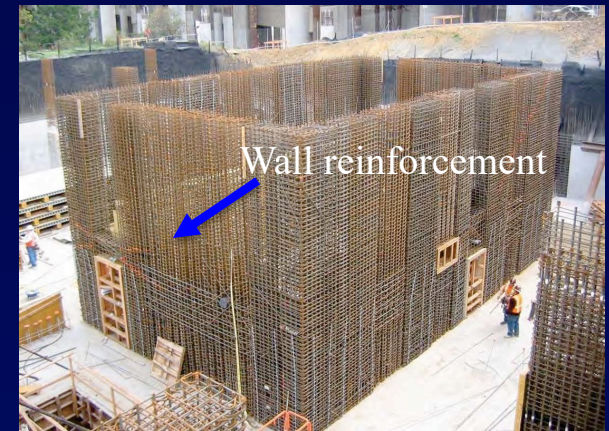
Thrust 3: Performance-based seismic design of new buildings



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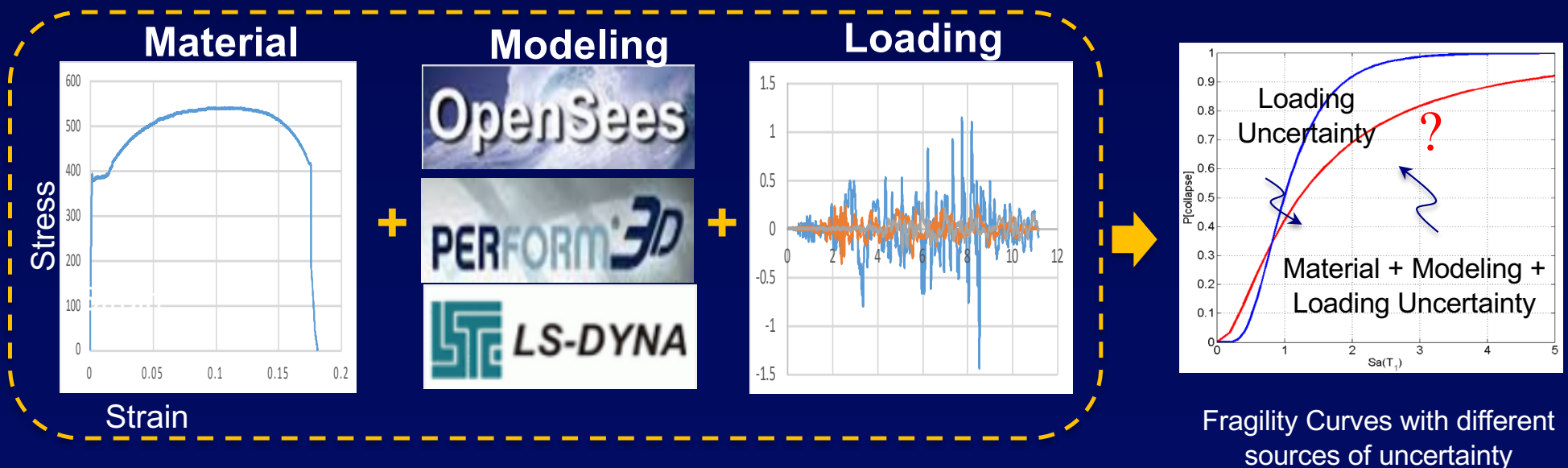
Seismic Implementation of High Strength Reinforcement Bars (HSRB) in Reinforced Concrete Structural Wall Systems (Underway)

- Problem: Reinforcement congestion in walls, beams, columns and joints is a big problem. HSRB has the potential to expedite construction time and decrease construction costs.
- NIST-sponsored work began a national effort to adopt higher strength reinforcement as an option for earthquake-resistant construction
- Wall and coupling beam components will be tested to generate vital data to develop numerical models
- Numerical analyses will be conducted to compare the collapse risk of structural wall buildings with regular and high-strength reinforcement
- New analytical tools and new building code provisions will be developed



Quantification of Material, Loading, and Modeling Uncertainties of Columns (Underway) *Thrust 3*

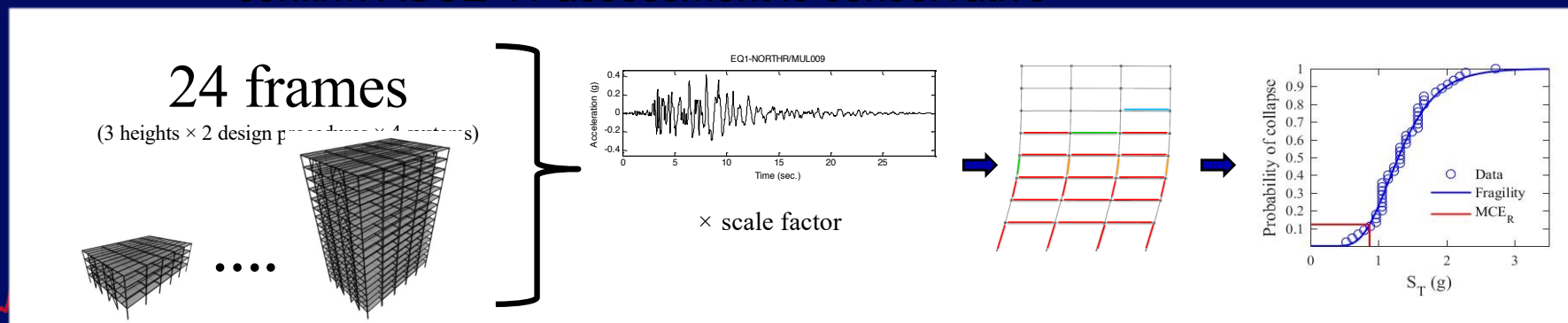
- Problem: *The combined impact of modeling, material, and loading uncertainty on the response of structures is less understood*



- Develop a framework to combine three sources of uncertainty to investigate the total uncertainty in the results at component and system levels for steel and concrete beam columns

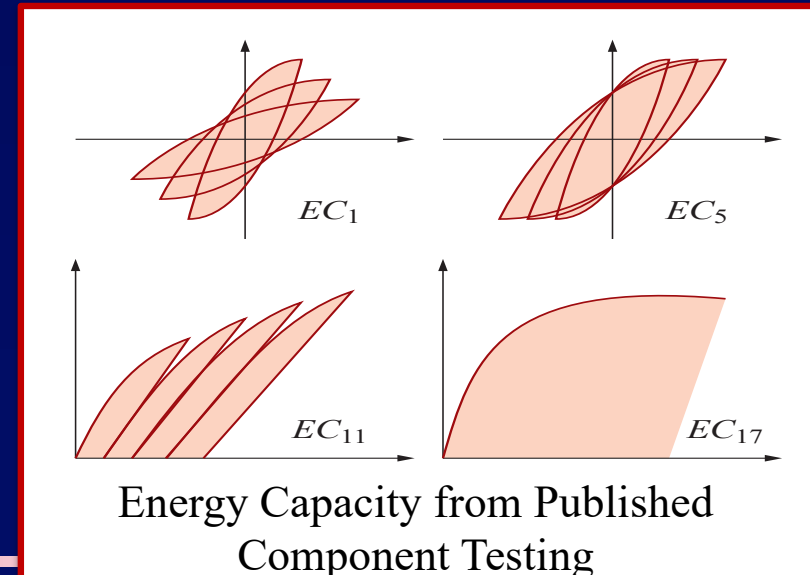
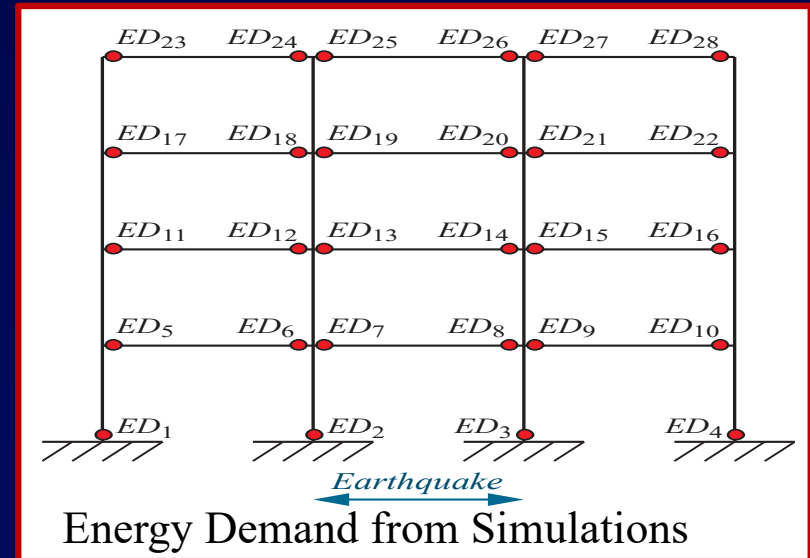
Collapse Assessment of Buildings under Seismic Loading (Underway)

- Problem: No clear understanding of the relationship between standards for new buildings and existing buildings
 - Previous work has *indicated* that current assessment standards produce collapse performance predictions that are conservative.
 - However, building collapse performance has not been systematically verified
- Determine the probability of collapse of a suite of steel buildings by using a series of increasingly severe ground motions
- Investigate sensitivity of modeling and analysis assumptions
- Suggests changes to ASCE 41 (or 7) based on findings
 - Results suggest buildings have probability of collapse less than 10%, and confirm ASCE 41 assessment is conservative



Energy-Based Collapse Assessment of Framed Structures

- Problem: Structural collapse in PBSD is commonly defined as a function of drift ratios, and not a function of the loading history
- Develop an analytical tool to assess structural performance and identify structural collapse using an energy-based approach
- Establish a new generation of performance-based assessment criteria capturing a component's dependence on loading history
- Provide results used to develop new assessment criteria for ASCE 41



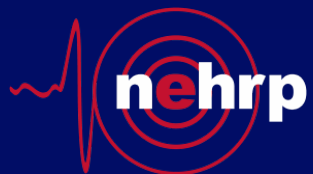
Thrust 4: 2EG Support for NEHRP

- All programmatic support for NEHRP comes from 2EG
 - The exception is Tina Faecke who is assigned to NEHRP
 - Support includes
 - NEHRP outreach led by Tina
 - Program coordination
 - NEHRP-level documents, e.g. IO report
 - Added programmatic work, e.g. functional recovery, comes at the expense of research progress

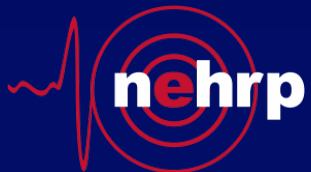


FY2019 2EG – Outreach Activities

- Ongoing outreach to the EQ Community since the November meeting
 - NIST exhibited at AGU in December
 - NIST Exhibiting at SEAOC convention in August 2019
 - NIST Exhibiting at ASCE Structures Congress in Orlando
 - NIST Exhibited at EERI in Vancouver
 - Organizing and a Research Symposium at NIST Concerning FFO Research for August 2019



Questions?



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